

ANNUAL ADMINISTRATION REPORT OF THE AGRICULTURAL
CHEMIST IN MYSORE FOR THE YEAR 1906-07.

SUGAR CANE.

19. *Object of the year's work.*—The chief object of this year's work with sugar cane was to standardise the piece of land selected for sugar cane growing. During the season of growth the very injurious effect of insufficient drainage was strikingly illustrated. The juice of the cane after being weighed and analysed was used for some experiments in sugar making. The result of these was to illustrate that with thorough skimming and liming to neutrality* a very good quality of sugar cane can be produced with comparatively simple contrivances, but that the losses incurred in doing this are very great. Improved machinery is necessary to overcome these. The results and the necessary descriptions are given below.

20. *Description of Plots.*—The wet area of the Experimental Farm at Hebbal contains a strip of land on the southern side which is on an average about one foot above the adjoining strip of land to the north of it. This strip, called Range "A," was divided into seventeen uniformly-shaped plots each having an area of one-tenth of an acre. The plots were nearly four times as long as wide and separated from each other by a raised path five links wide running the entire length of the plot. The map is given in the sixth Annual Report. On both sides of this range is a drainage channel. That on the south side was only one foot deep in places. On the southern side is also a small irrigation channel from which each plot can be watered as desired, and beyond the drainage channel but within three feet of it in places is one of the main irrigation channels of the tank. The eastern end and part of the western end of this range are also cut off by a drainage channel from the surrounding land. But in the south-western corner there is no drain.

21. *Influence of drainage on sugar cane.*—Throughout the entire range the southern ends of the plots were decidedly inferior to the remainder of the plots. As stated above, the drain on this side was not as deep as it should have been, being in places only one foot deep. Besides there were two irrigation channels near that side of the range, the one used occasionally when the cane required watering was close up to the plots. The other was separated by the drainage channel, a dam and a narrow strip of land varying in breadth from a few inches to a little over 50 feet. Wherever this strip of land was narrowest and the drain the shallowest the crop on the southern end of the plots was poorest. The cane was planted in rows running lengthwise of the plot, north and south, and at right angles to the long drainage and irrigation channels. To form some idea of the loss sustained by the crop on the southern part of the plots being stunted the centre five rows of plot No. 10 were

* The juice is limed to neutrality when, as described on page 13 of the sixth annual report, blue litmus paper is not turned red when dipped into the juice and red litmus paper is not turned blue when dipped into the juice.

divided into three equal parts: the weight of cane from the various portions was as follows:—

Section			Weight of cane cut lbs.	Equivalent to tons per acre
Southern	...	...	198	6 $\frac{1}{2}$
Middle	...	...	650	22 $\frac{1}{2}$
Northern	...	...	904	31 $\frac{1}{2}$

With the previous crop of paddy the southern part of these plots had a decidedly better crop than the northern portion. This difference in the crop of sugar cane could not therefore be due to the soil as such, being poorer on the southern end. The suggestion, which might be made, that the heavier crop of paddy had taken more out of the land and that therefore there was not as much available plant food there when the sugar cane was growing, appears improbable when we remember that in the other two ranges of the wet area which had been cropped with paddy this year as well as last year the plots which had given the best crop the first time also gave a crop much above the average the second time. A similar though not quite as striking an illustration of the injurious effect of the proximity of subsoil water on the growth of cane will be noticed by comparing the yield from plots Nos. 1 and 2 with the average of the other plots in Table No. II in the appendix. Plot No. 1 is that nearest to the tank bund. Between it and the bottom of the bund is a road 24 feet wide, a shallow drain about 1 $\frac{1}{2}$ feet deep, for about two-thirds of its length, a narrow triangular strip of land about 10 feet wide as the base and an irrigation channel. It gave the third-highest yield of paddy in its range last year, giving 10 per cent above the average. This year it gave by far the lowest yield in the range, being 33 per cent below the average. This may in a small measure be due to the fact that the cane on this plot did not germinate well and a portion of the plot had to be replanted to ensure an even stand. But the chief reason is, I think, due to the plot being so near to the tank bund and not being drained deep enough. These indications, if confirmed, would prove that it is highly objectionable to grow paddy and sugar cane in adjoining plots unless there is a deep drain separating them.

22. The necessity of having sugar cane lands well drained is generally recognised in all cane sugar exporting countries. And those persons who have seen the effect of shallow drainage on this year's sugar cane crop on the Experimental Farm at Hebbal near Bangalore, and realize that the stunted growth there was really caused by poor drainage, ought to spare no pains to have their sugar cane lands well drained. This is, I believe, one of the principal things on the cultivation side of the sugar cane industry of Mysore to be learned by its raiyats. In Mysore sugar cane is often treated too much like paddy.

23. *Cultivation.*—The land was ploughed with a light iron plough to a depth of about six inches. Furrows were then ploughed three feet apart (running north and south, the length of the plot) about six inches deep. In these 17 lbs. of black castor cake were evenly spread and mixed with the soil at the bottom of the furrow. One row of whole cane was laid on the loosened bottom of the furrow. These were cut, where necessary, to straighten them and lightly covered with loose earth. Water had been run along the furrows and these allowed to dry sufficiently to prevent puddling of the soil before applying the black castor oil cake. Black castor was used as it was the cheapest manure available at the time, considering quality. It contained 3.99 per cent of nitrogen.* This gave 88 lbs. of nitrogen per acre or nearly 1 ton of oil cake per acre. There were 13 rows of cane in each plot. The cane was planted on the 9th and 10th of March and the first shoots appeared above ground on the 17th of that month. On the 11th of April the stand was fairly even except in plots 1 and 2 where considerable vacancies existed. All the vacancies were replanted on this day, and the first shoots of these were seen nine days later. The cane was earthened up on the 22nd to 25th of June and cultivated twice before that.

24. *Appearance of crop during growth.*—As already said, the southern portion of all the plots, those next to the irrigation channel, were decidedly inferior to that

* Nitrogen is the chief manurial constituent of oil cakes.

on the north, where a drain 2½ to 3 feet deep carried off the subsoil water. Plots No. 1 and No. 2 were also decidedly inferior in appearance throughout the year. The cane on the northern portion of plots Nos. 6 to 11 appeared to grow more luxuriantly than that on any other part of the field. But before it was full grown some of it lodged.

25. *Pests*.—A borer entering the cane through its growing point did some damage, especially in the earlier stages of the growth of the one. All stalks which were seen to be affected were cut out and burned. Later on rats and jackals did some damage where they had most cover, especially in the lodged portion.

26. *Harvesting*.—The object of this year's experiment being chiefly to see in how far the various plots would produce the same weight of sugar when the cane grown on them was treated in the same way, it was necessary to cut and crush the cane on every plot as nearly as possible at the same time; for as long as the cane was growing it would probably change in weight and composition from day to day, and the results obtained from a plot harvested at the beginning of a month would not be strictly comparable with those from a plot harvested in the middle or the end of the month; the crop on the one plot would have had two weeks or a month more in which to improve or deteriorate, as the case might be. But as we had only two small bullock mills with which to crush the cane and four ordinary local small pans in which to evaporate the juice, as the juice in each pan had to be weighed, and analysed, the cane, the tops and the bagasse represented by the juice in each pan had to be weighed separately and the resultant jaggery (Gur) or massecuite (Rab) to be weighed, and analysed, it was evident that the harvesting would take a very long time. All that could be done was to take a row from each successive plot at a time and thus make the average age at which the cane was cut on each plot the same. The plot on which the first row was cut would be the last to be completely harvested. Similar arrangements had to be made to compensate for the difference there was in the mills. And with all, every precaution had to be taken to prevent samples being mixed up. It would lead too far to describe the methods adopted in detail. It is sufficient to say that this year they worked very satisfactorily indeed, because the cane changed but little in composition during the two months it was being harvested. Whether it changed in weight it is impossible to tell, but probably what change there was, was slight. But as the cane does not necessarily remain constant in composition and weight nor change uniformly during the harvest season, it is impossible to be sure of being able to satisfactorily compensate for the inaccuracies produced by a protracted harvest season. I confidently hope therefore before long to have the appliances to harvest the entire range of cane plots in a week or two. With appliances permitting the cane of a whole plot being milled at a time and all the juice being evaporated in one vessel, the analytical and other work connected with the harvesting would be reduced to one-tenth of what it now is and the results obtained would be more valuable.

27. *Composition of cane*.—The per cent of juice extracted from the cane was on an average 64·31, and the percentage of bagasse,* 32·31. This leaves a wastage of nearly 3·6 per cent caused principally by the loss of juice during milling and evaporation of moisture from the bagasse after milling.

28. The solid part of the cane, "the framework" and cell walls which is called mark, was larger this year than in previous years. It constituted 10·41 % on an average of the weight of the cane. It varied from 8·3 % on a part of plot No. 7 to 12 % on a part of plot No. 14. We were unable to find any relation between the percentage of mark and the size of cane or the composition of its juice. But on account of press of work the mark was only determined in a little over 20 % of the samples of cane. The lowest percentage of mark, viz., 8·3 %, was found in the cane which had lodged most and that was where in the early stages the cane had grown most luxuriantly. The lodging was undoubtedly largely due to the small percentage of mark, but that this small percentage of mark was due to the vigorous growth of the cane in its early stages is not necessarily the case, for in previous years we have found a lower percentage of mark than this in cane which did not grow luxuriantly at any time of its growth.

* The refuse cane after it has been crushed.

29. The composition of the juice was fairly uniform notwithstanding that the harvesting season extended over two months. Excluding the badly lodged cane the cane sugar* content varied from 19.25 % to 21.75 % and the glucose* or grape sugar from 1.22 % to 0.18 %. In all cases where the glucose exceeded half a per cent some fermentation had probably taken place. There were several small patches on which the cane had lodged more or less. This cane as well as a large portion of that injured by rats or jackals was harvested together with the sound standing cane, and most of this injured or lodged cane had had a high percentage of glucose, probably due to fermentation. This in itself would account in a large measure for the high percentage of glucose sometimes found in the juice; besides the juice from the injured cane would probably start at once fermentation of the whole lot of juice of which it formed a part. By referring to Table No. II in the appendix it will be seen that the average composition of the juice from the entire field was 20.59 % of sucrose and 0.47 % of glucose. This indicates that the cane is of exceptionally good quality.

30. *Lodged cane.*—The badly lodged portion of cane was harvested separately. It contained 16.1 % of cane sugar and 2.16 % of glucose. Besides this great reduction in quality there was a very material reduction in the total weight of the cane harvested. This lodged portion of cane was at the northern end of the plot where all the plots produced a much better crop than on the southern end. The amount of cane harvested from this patch was equivalent to 4,486 lbs. per plot. The total yield of the plot was 5,262 lbs. But making allowance for the difference on crop on the northern and southern portions of all the other plots the loss due to the cane having lodged is at least one-third, if not half, of the total weight of cane. And the total weight of sugar produced is far short of being one-half of that which would most likely have been produced if the cane had not lodged.

31. *Comparison of plots.*—As already stated, the cane on plots No. 1 and No. 2 was decidedly poorer in appearance throughout the year than that on the other plots. Plot No. 1 produced nearly 25 per cent less sugar than the average of the entire range, and plot No. 2 gave over 22 per cent less than the average. If these continue to yield such poor crops in future they will have to be excluded from the experimental sugar cane area. As already mentioned when speaking about drainage, the paddy produced by these plots in the previous year was up to the average. In fact plot No. 1 was 10 per cent above the average and stood third in yield. With the exception of these two all the plots gave fairly uniform crops. This indicates that the range is probably well suited for experiments with sugar cane. Barring plots No. 7 and No. 2, the variations from the average yield find their extremes in plot No. 7, which is about 7 per cent below the average, and plot No. 13, which is about 13 per cent above the average. Strange to say plot No. 13 which gave the highest yield of sugar cane this year, gave all but the lowest yield of paddy last year. If these results are confirmed they will furnish another illustration that paddy cannot be used as a crop for standardizing plots intended to be used for experiments with sugar canes. Plot No. 14, which gave by far the poorest yield of paddy last year (giving more than 25 per cent below the average) gave slightly above the average weight of cane sugar this year.

32. While in reality the plots, when taken as a whole, gave surprisingly uniform returns, they seemed, when judged by their appearance from the outside, to vary very much indeed. This impression was not much improved when pushing one's way through the standing cane. When only a few rows were left standing on the centre of each plot and a good view could be had of them from all sides they appeared to be fairly uniform. But even then they did not appear to be nearly as uniform as they were in reality. I wish to draw special attention to this because some experimentors in India have suggested that a sugar cane crop might be judged sufficiently well by the eye. If a reliable assistant cannot be found to weigh the crop the experimenter should, in my opinion, weigh the crop himself, and if a reliable

* The juice of sugar cane contains sucrose and glucose in addition to water, colouring matters, aluminoid substances, ash, acids and a number of other substances not referred to here. Sucrose or cane sugar is absolutely pure ordinary sugar. Thoroughly dry white refined sugar is nearly pure sucrose. Glucose is a name given to a group of other sugars which is not as sweet to the taste, does not crystallize as easily and is simpler in composition than sucrose. It constitutes one of the impurities of sugar, makes the jaggory soft and liable to run in the monsoon and tends to prevent the ordinary sugar from crystalizing or becoming solid.

weighing machine cannot be secured it would, in my opinion, be useless to carry on any experiment with cane in which the yield of cane per acre forms any part.

33. *The effect of stunted growth on the composition of Cane.*—As already mentioned in para 21 on page 3, when speaking about the effect of imperfect drainage on the growth of cane, one strip of five rows on plot No. 10 was divided into three equal parts. Each was harvested separately. The southern portion produced less than one-fourth of the crop grown on the northern third. The object of reaping these parts separately was chiefly to see what effect the stunted growth had on the composition of the cane. A popular belief is that stunted cane is relatively much the richer. By comparing the composition of the juice from this cane it will be seen that such is certainly not always the case. All the cane was cut and analysed the same day. The following is the result:—

EFFECT OF GROWTH OF CANE ON ITS COMPOSITION.

Description of sample	Weight of cane harvested	Yield per acre	Mark	Juice	
				Sucrose	Glucose
Plot No. 10 rows 5 to 9—					
Southern one-third	lbs. 198	Tons 6'89	Per cent 11'43	Per cent 21'05	Per cent 19
Middle one-third	650	22'63	10'45	21'65	38
Northern one-third	904	31'47	11'92	20'10	68

The middle third of these rows is about an average crop. It has a higher cane sugar content and a lower percentage of mark than either the other two. That in this case the cane which had grown the most vigorously contains the highest per cent of mark is worth noting and is encouraging. It certainly does not support the view that vigorous growth always implies a low mark content. A higher percentage of mark than is required to keep the cane from lodging is of course objectionable. But to have one or two per cent mark more than is actually required is very much better than to have so little mark that the cane lodges. The more vigorous the growth of the cane the more danger there is of the cane lodging on account of the greater weight which has to be supported. If the conditions which favoured a heavy growth of cane also favoured a low or inferior mark formation it would be very discouraging indeed. But the figures obtained this year indicate that such is certainly not always the case.

34. No conclusions can be drawn from the difference in the glucose content. There appears to be an increase in the glucose the heavier the crop. But this is probably due to a larger number of canes having been injured by rats or jackals in the places where the cane stood thickest. Any serious injury to the cane implies of course a reduction of sucrose and increase of glucose. However, the figures do indicate that stunted growth does not necessarily imply a higher sugar content and a higher percentage of mark than would otherwise be the case.

35. *Ripening of Cane.*—By referring to Table No. 1 on page 11 of the sixth Annual Report it will be seen that the cane in those experiments was at its best for less than a week, the cane sugar content being nearly 2 per cent lower a month before it reached the maximum and considerably more than 2 per cent below the maximum within a month after it had reached that stage. These were experiments made on samples of six canes each. This year the harvesting season lasted over two months. Below is given a table giving the average composition of all the canes cut in each successive week of the season.

The average composition of the cane cut at different times during the harvest season:—

Week of harvest season.	Sucrose.	Glucose.	Total solid.
1st week	...20'25	41	21'02
2nd "	...20'76	33	21'37
3rd "	...20'89	44	21'71
4th "	...20'60	46	21'51
5th "	...	...	...
6th "	...	...	...
7th "	...20'96	50	21'88
8th "	...20'73	68	21'82
9th "	...20'49	67	21'50

* During the 5th and 6th week, after beginning the cutting of cane other pressing work had to be done, and no cane was cut.

36. By comparing the above figures it will be noticed that the cane crop was wonderfully uniform in composition during the entire harvest season. During the first week the cane does not appear to have been quite mature and as the season advanced there was a slight increase in the glucose content. The difference between these results and those recorded in the sixth Annual Report is no doubt due to the fact that in the results of two years ago average canes were selected each time. Those results indicate therefore what takes place in the individual canes. This year's results show what takes place in a field where the stalks are not all of the same age. Some are still improving in composition while others are already deteriorating. The average of a field therefore remains nearly constant for a much longer period of time than the individual canes.

37. *Influence of variety on deteriorations of Cane after reaching maturity.*—Varieties differ very materially in the rate with which they deteriorate after maturity. In one of the varieties grown on the Farm the individual canes varied only three-quarters of a percent in their sucrose content during four months' time. During all that time the juice showed a cane sugar content of 21% or more. Another variety remained comparatively constant in quality for six weeks. During that time the individual canes varied about 1% in sucrose (cane sugar) content, viz., from 19.8% to 21%. Two other varieties deteriorated again as rapidly as the variety experimented with two years ago. Naturally it is desirable to cultivate such varieties, other things being equal, which remain at their best for the longest time.

SUGAR.

38. In para 42, page 21 of my sixth Annual Report, are given some of the reasons why it is necessary that India should produce sugar instead of jaggery or gur or gull if cane growing is to receive the attention it deserves. As stated there the quantity of sugar imported into India in 1903-04 was a little over 106,000 tons. Since then it has been rapidly rising and was last year (1905-06) over 413,000 tons, an increase of nearly 300% in 12 years. In the past two years there has been an increase of 97,000 tons in the imports or an increase of over 30% on the 316,000 tons imported two-years ago. And most of this (over 90%) is refined sugar. Last year's imports show an increase in one year of over 19%.

39. To form some idea of the constant increase in the importation of sugar which is going on, I quote the following quinquennial averages of imports in tons and their values for the past 20 years:—

Years	Average import of total sugar Tons	Increase over previous period	Average value per year in lakhs of rupees.	Increase over previous period
	Tons	%		%
1886-91 ...	98,307	...	231	...
1891-96 ...	115,223	17	279	21
1896-01 ...	201,951	75	419	50
1901-06 ...	330,175	63	629	50

Last year's imports amount to nearly 2½ lbs. of sugar for every person living in India, or a little over 3½ annas per head. When these quantities per individual are compared with the totals of 926,365,440 lbs. and Rs. 7,77,45,199, they appear very insignificant and show that while the total imports are enormous there is every prospect of the present steady advance in the imports continuing unless something very energetic is done to check them. These constantly increasing imports of refined sugar indicate that there is a strong and growing demand for refined sugar which is not being supplied by the present sugar industry in India. As there are enormous losses in the practice of boiling the sugar cane juice first into jaggery and afterwards refining this, as pointed out in several of my previous reports, it is not surprising that that method which has been practised in India for a considerable period of time is unable to check to any appreciable extent the imports of sugar into India. The only course open is to produce centrifugal sugar directly from the sugar cane juice and not boil it into jaggery first. This course has been

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Advocated by me ever since arriving in India, and every year's work has placed me in a position to urge that course more strongly than in the previous year.

40. "*Hadi's process*."—The Department of Agriculture of the United Provinces have also studied that problem for some time, and one of their Assistant Directors, Mr. S. M. Hadi, has advocated a system of clarification in which no lime is used, the separation of the scum is assisted by the addition of the mucilaginous extract of the wild "Bhendi" (a hibiscus) and a little bicarbonate of soda and the clarified juice is evaporated by a continuous process in a pan somewhat similar to that used by maple sugar makers in America and sold by manufacturers under the name of "American evaporators." The "Hadi system" is described in detail in Bulletin No. 19 of the Department of Agriculture for the United Provinces. The plant has been exhibited at the Calcutta Exhibition and has attracted a great deal of very favorable attention. It was also exhibited to the members of the Board of Agriculture at Cawnpore and the quality of sugar it turned out has been much admired by all expressing an opinion on the same. To me it appeared, however, that the process must lead to a great loss of cane sugar by inversion into glucose. Mr. Hadi quite realized the advantage of using lime if that could be done without injuring the colour of the sugar produced, but his experience was that the use of lime invariably affected the colour very injuriously.

41. As the sugar turned out by Mr. Hadi was of exceptionally good quality, and as the loss of sugar due to inversion had never been determined when using this particular process, I determined to try it and check it carefully at the Experimental Farm this year. Instead of the continuous open evaporator used by Mr. Hadi I used the ordinary open pan used by the Mysore raiyat, and instead of the extract of the wild Bhendi I used that of the cultivated variety, *Hibiscus esculentus*, which gives a mucilaginous extract very similar if not identical with that of the wild variety used by Mr. Hadi. However, Mr. Hadi also uses the cultivated variety. In every other detail the process was carried out as in Cawnpore.

42. *Loss by inversion in the "Hadi process."*—As will be seen from Table No. IV in the appendix, there was, on an average, an inversion of over 22 per cent of the sugar into glucose when using the "Hadi process;" while when using the ordinary process, that of fully liming the juice, the loss of cane sugar from inversion was only 6.59 per cent, as given in Table No. V in the appendix. In other words, the use of the "Hadi process" implied that 1,095 lbs. of cane sugar per acre were totally lost when compared with the ordinary process, and that about an equal quantity became irrecoverable from the molasses; in all therefore 2,190 lbs., or nearly one-third of the total sugar in the juice were lost when using this method when the molasses was used for making "second sugars." This at Rs. 2-8-0 per maund of 28 lbs., the price we obtained for the sugar produced this year, amounts to Rs. 195. Mr. Hadi makes no second sugars and boils the molasses from the first sugar into jaggory. If he can sell that at a good figure his loss would be materially reduced. But from a sugar-making standpoint it would still remain unaltered, or rather become worse on that account, because further inversion would take place when boiling the molasses to jaggory. Unfortunately the juice used for these experiments contained a larger percentage of glucose than that used for making the sugar in the ordinary way. Of course that has been taken account of when calculating the loss of sugar by inversion. But it has frequently been noticed that some juices containing a high percentage of glucose to begin with lose more sugar by inversion when boiled down to jaggory (notwithstanding that they are limed in the same way) than other samples of juice containing less glucose to begin with. Why this should be the case has not yet been determined. That it is a fact may be observed by comparing the average loss by inversion given in Table No. III with that in Table No. V. In both the juice was fully limed. But the average percentage of glucose of the juice in Table No. III is considerably lower than that of the juice used, for the results given in Table No. V and the loss from inversion in Table No. III is only about two-thirds of that in Table No. V, being 4.5 per cent in the one and 6.5 per cent in the other. But even making a most liberal allowance for this unfortunate circumstance, the net results will not be materially affected.

43. *Colour of sugars from the "Hadi process" and that made in the ordinary way.* The great advantage claimed for the "Hadi process" is that it will produce a sugar of much lighter colour and much finer and softer grain than when the juice is limed. To test this point the colour of the samples of sugar made by the "Hadi process"

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were compared with those made in the ordinary way, except that they were washed in the centrifugal with the soapnut decoction used in the Hadi process. The result was that the sugar made in the ordinary way was on the average 6 per cent lighter in colour than that made by the "Hadi process." These tests were made with both the Lovibond tintometer and the Nesler tubes. When both samples were washed with water instead of soapnut decoction there was on the average no difference in colour. Both samples were 30 per cent darker than the average of the sugars boiled from fully limed juice washed in the centrifugal with soapnut decoction. The unwashed sugars were also alike in color, both being 137 per cent darker than the ordinary sugar washed with soapnut decoction. The sugar produced by the Hadi process had therefore no superiority in colour over that boiled in the ordinary way.

44. *Fineness of grain in sugars.*—The fineness of grain depends principally on the rapidity with which the massecuite or rab is cooled down after boiling and the concentration of the massecuite or rab. The more rapidly it is cooled and the more concentrated the massecuite or rab is the finer the grain. Another factor which affects the size of the grain of sugar is the impurities in the massecuite. The more impurities in the massecuite the less of the sugar will separate out and the finer the grain. The last of these factors is the only one which differs in the two processes, and as the massecuite made by the "Hadi process" is the more impure on account of the large amount of glucose it contains, that process has a tendency to produce a smaller grained sugar. But by stirring the massecuite made in the ordinary way a little longer than is done in the "Hadi process" an equally small grained sugar can be obtained if that is desired. But from a sugar manufacturer's standpoint it is highly desirable to have a large grain or crystal of uniform size. It gives a better outturn of sugar and centrifugals more easily. Besides a large grained sugar generally contains less glucose, in other words, it is purer. If the market demands a small grained sugar it can, I believe, be produced more cheaply by grinding a larger grained sugar than by producing a very fine grained sugar to begin with.

45. *Losses other than by inversion.*—Provided there is no filter press, chief of these losses is the sugar removed in skimming. But no reliable figures are available under that head this year. The chief object this year was to skim as thoroughly as possible and as time was very pressing the filtration of the skimmings was not carried out with that care it should have been done to get results worth publishing.

46. *Filtration of scums.*—We have not as yet found a simple method of filtering the skimmings which is sufficiently rapid and effective, when the juice is skimmed as thoroughly as was done this year, to recommend it. There has been, as far we could see this year, no difference in the amounts and consistency of the skimmings in the two processes.

47. *Sugar lost in molasses.*—There was, however as already mentioned, a difference in the amount of cane sugar lost in the molasses. Although the massecuite (rab) was boiled a little "harder" in the "Hadi process," as is indicated by the glucose ratio of the molasses, there was a considerably larger proportion of undecomposed sugar left in the molasses by this process than by the ordinary process. In the "Hadi process" there were 37.12% of the total cane sugar left in the molasses after the first boiling and in the ordinary process 34%. The glucose ratio of the molasses from the massecuite prepared by the "Hadi process" was 1 to 1.24, that is for every pound of glucose in the molasses there were 1.24 lbs. sucrose cane sugar present. In the ordinary process the ratio was 1 to 3.55. These figures imply that a very much larger amount of second sugars can be obtained out of the molasses obtained by the ordinary process than that by the "Hadi process." The molasses has not yet been reboiled, but the past experience indicates that if a definite quantity of Hadi process molasses would give .2 lbs. of sugar the same quantity of ordinary molasses would give about 30 lbs. second sugar.

48. *Conclusions.*—On every point on which we have examined the two processes the ordinary process has either been equal to or superior to the "Hadi process," and in most cases decidedly superior. The skimming with the "Hadi process" was on the whole a little easier, but we have been unable to make that a comparative test. All the work was carried out under my direction by Mr. Ramachandra Rao, the Farm Manager. He had no previous experience with either process, and both processes had therefore an equally good chance in his hands. That he did his work

well may be judged from the fact that the sample of sugar turned out by the "Hadi process" was as good as that turned out by Mr. Hadi himself, and that the sugar by the ordinary process was much superior to any which has been boiled here in previous years.

49. The secret of making a light-coloured sugar is very careful skimming and skimming at the right time.

50. *The advantage of the use of bicarbonate of Soda, in the "Hadi process."*—At first sight it may be difficult to understand what possible good there can be in adding a little of a solution of bicarbonate of soda to the acid juice a short time before the latter comes to the boil. It must increase the soluble ash in the massecuite and thus would keep some of the sugar in the molasses which would otherwise crystallise out. The quantity added is too small to appreciably affect the acidity of the juice. It is enough, however, to produce a large number of small bubbles of carbonic acid gas, and some of these get caught in the small particles of "scum" which have already formed but have not yet risen to the surface. Or rather, these bubbles are most easily formed where these solid particles exist. And in rising to the surface they carry the little solid particles with them. The bicarbonate of soda therefore assists in the rapid formation of a good "blanket," as the scum is technically called when it is packed together on the surface of the juice. Possibly the mucilaginous extract from the Bhindi may make this blanket a little tougher than it would otherwise be. But if it does so we have failed to notice that fact.

51. The price realized for the sugar produced this year which was offered for sale was Rs. 2-8-0 per maund of 28 lbs. or only one anna less than refined sugar could be bought for at the same time in the same market. The best quality of jaggory was sold for Rs. 1-8-0 per maund. The juice from which it was made was skimmed to the same extent and in the same way as that from which the ordinary samples of sugar were made.

PLANT FOOD REMOVED BY SUGAR CANE.

52. In para 50, page 25 of last year's report, octavo form, it was promised that the juice, leaves, top and trash of sugar cane should be analysed this year to determine the amount of plant food actually removed by sugar cane from the soil. This has been done, and the results are given in Tables No. VIII, No. IX and No. X in the Appendix. The results are calculated on the crop actually grown on the spot where the samples for analyses were taken. That was at the rate of 24.95 tons per acre. From the tables referred to it will be seen that the total amount of plant food removed in the portion of cane above ground (unfortunately the roots could not be analysed this year) is 55½ lbs. of both nitrogen and lime, 68½ lbs. of phosphoric acid and 190 lbs. of potash.

53. These figures therefore show that the sugar cane removed three times as much potash as it did of any of those other constituents of the soil generally supplied to it in fertilizers. The tops and the green leaves together contain more than half of this amount, the green leaves which are usually fed to the bullocks containing most of this.

54. Of the total nitrogen removed fully one-third is in the begasse. But as the begasse decomposes very slowly even if ground up to a fine powder little of this will be available for future crops even if applied to the soil. Undoubtedly it is much more valuable as fuel than as a manure.

55. It may appear strange to some that the dead leaves or trash contained more than one-third of all the lime removed, notwithstanding that they constituted less than 6½% of the total weight of substance removed from the field. The proportion of potash in the dead leaves is not nearly so great, being only a little over 11%. Comparing with this the relative amount of potash and lime in the green leaves we find that they contain for the same amount of lime more than 2½ times the amount of potash. This indicates in conjunction with the figures contained in Table No. VIII that the lime accumulates in the leaves as they are growing and remains there. That on the other hand the potash in the dying leaves is removed and used again in other parts of the cane. This is quite in conformity with the facts observed elsewhere. But notwithstanding the fact that the potash did not remain to any very large extent in the dead leaves, while the lime did, the cane as a whole contained four times as much potash as lime.

56. These facts certainly indicate that the crop of sugar cane drew heavily on the potash in the soil, and may possibly account why it is found advantageous to give such heavy dressings of oil cake in some places in India if no other fertilizer supplying potash is used. The soil has no doubt a great deal to do with this and probably the variety of cane also. It is possible, however, that where these large applications of oil cake are given sufficient attention is not paid to the potash or phosphoric acid requirements of the cane. Should this be the case it may perhaps be possible to reduce the cost of manures for sugar cane very materially without reducing the returns. I need not say that manurial experiments with cane will be begun as soon as possible and that the testing of this point will form the basis of these experiments.

57. *Tables.*—In the appendix are given a number of tables which practically speak for themselves. Table No. 1 contains the weights of sugar cane, tops, bagasse and jaggory or massecuite, actually obtained from the plots. The composition of the juice and jaggory are also given. A small portion of the cane from each plot which was not milled with the bulk of the cane is not included in these figures. Table No. II gives the total yields each plot would probably have given if this cane used in other ways had also been milled at the regular harvest time. For this calculation it is taken for granted that the cane used for these other purposes had the same composition as that which is given in Table No. I. Table No. III gives the loss of cane sugar due to inversion while boiling down the juice for all the samples of juice limed to neutrality. Table No. V gives the decomposition of sucrose into glucose during the latter part of the season when the glucose content of the juice was relatively higher than in the early part of the season. It has been noticed before that juice which contains a lot of glucose to begin with frequently loses more sugar by inversion during boiling than juice which has little glucose, notwithstanding that both are limed in the same way. Table No. IV shows the results obtained when boiling sugar by the "Hadi system," and Table No. V gives the results obtained when boiling sugar from similar juice in the ordinary way. Table No. VI groups together all the samples of juice milled during the same week of the harvest season, giving the composition of the juice and the date on which it was milled. And Table No. VII gives the results of the analyses of the juice from two of the varieties of cane grown on the Farm when cut at different periods. Six average canes were selected from time to time from each plot. These were cut and the juice analysed to find out when the cane was ripe and how long it would remain at this its best stage.

PADDY.

58. In Table No. 1, page 6 of last year's report, are given the yields of grain obtained from the wet area in the first two crops of paddy. It was intended to plant this year the same variety of paddy as that used in 1906. But the Farm Manager had not sown enough seed in the nursery to plant the entire area in the usual way. To save time a "sixty days" paddy which had been imported the previous year from Madras was used instead. This grew fairly well until after it had shot into ears, though not as vigorously as the "Chintamani Sannabhata" had done the previous year.

59. When the harvest time approached it was found that practically none of the ear heads had filled. A little later fresh shoots were sent up, and in the hope that these might possibly produce grains the experiment was tried of letting the paddy remain on the field until these new shoots were mature. But this experiment was a failure as no grain formed in the second crop of ear heads.

60. The transplanting of the paddy from the nursery to the experimental plots began on October 8th, and was finished on the 15th of October. The paddy was cut on the 7th and 8th of February. No manure was used for this crop and none had been used for the two previous crop of paddy.

61. Before it was found out that the paddy on the Farm had formed no grain, several samples of paddy which had not formed grain were sent by raiyats from various localities in the State with the request to identify the disease and give a remedy for the same. But Dr. Butler, the Imperial Mycologist, was unable to find any trace of disease on the samples sent him. These included a sample from the Experimental Farm.

62. Before sending these samples to Dr. Butler I examined them as carefully as I could. But the only abnormal thing I could find was that the cells of the straw were full of starch. Apparently the starch which is usually stored in the grain had been formed, but there being no grain in which it could be deposited it remained in the straw. This was therefore of a higher feeding value than it would otherwise have been. That is, however, a poor compensation for the loss of grain.

63. Several suggestions have been made as to the possible causes for the non-formation of the grain. One of these was that the variety had been newly imported. But as the seed from which this crop had been produced had grown on another part of the same farm the previous year, and the crop of which this seed formed a part had been a good one, this could hardly be the cause. Another suggestion was that the climatic conditions at the time when the paddy was flowering were possibly very abnormal. Nothing very abnormal was noted about the season, and the fact that the second crop of ear heads (which flowered several weeks after the first crop had flowered) also failed to produce grain, speaks against this theory. A third suggestion was that the land might have been in bad manurial condition, having had no manure for at least three successive seasons. Some of the land was no doubt very poor. But the best plots had produced more than at the rate of $1\frac{1}{2}$ tons of grain to the acre per season for the two previous seasons, and the area as a whole had shown no deterioration in its crop return the previous season. Besides, if the failure to form grain had been due to this cause, the best plots would undoubtedly have produced whatever little grain was produced. But in both ranges the best plots gave absolutely no grain, while in range B the poorest plot gave the most grain—2 lbs. 9 oz.—and in range C an average plot gave the most grain, 5 lbs. 5 oz. To none of these reasons in themselves can, I think, be assigned the failure to produce grain. If any of them have any bearing on the subject at all they can only have formed one of several causes which may have worked together to produce this very undesirable result.

64. The next crop of paddy was still growing on the experimental plots when the official year closed. It was nearing maturity and the grains had formed well.

DRY AREA.

65. *Ragi*.—All the plots which may possibly be used for experimental purposes in the dry area were uniformly treated and shown with ragi without using manure or growing any leguminous crops between the rows. The crop was cut on November 15th and 16th. But owing to the large amount of work connected with the sugar cane harvest this year the thrashing of the ragi was not finished at the close of the official year.

66. During the time the ragi was growing there was a considerable amount of rain, and the subsoil water came to within 18 inches of the surface at a spot 4 feet 7 inches above the high water level of the tank. There was also a considerable wash of surface soil shortly after sowing before the ragi could protect the soil. These are some of the factors which have contributed to considerably reduce this year's crop. As in the previous year, there is a considerable difference in the crop produced by the various plots. But all this will have to be reported on next year.

GARDEN CROPS.

67. Nearly all the Garden crops did very poorly this year, the heavy rains were largely to blame for this. Ground nuts and Brinjals suffered badly from disease. Turmeric and ginger did fairly well. Sweet potatoes gave decidedly below an average crop. Below are the crops of sweet potatoes harvested for the past four years:—

Year	New Jersey	Nansemond	Virginia
	lbs. per acre	lbs. per acre	lbs. per acre
1903	14,170	14,870	13,050
1904	14,170	8,760	8,600
1905	22,100	20,880	21,050
1906	7,370	12,000	5,480
1906	11,400	9,300	10,200
Average	13,840	13,160	11,670

68. As will be noticed, the new Jersey gave the highest average yield.

69. Onions (Yadgiri) did very well; one plot yielding at the rate of 25,000 lbs. per acre and another plot at the rate of 19,000 lbs. per acre. Some of the largest onions weighed 1 lb. each.

COTTON.

70. *Carovonica cotton*.—Both the No. 1 and No. 2 varieties continued to grow, though not as well as last year. Those planted in October 1905 gave on an average of a little over $1\frac{1}{2}$ oz. clean cotton per tree during the year. Those planted in April 1906 gave a little under $1\frac{1}{2}$ oz.

71. A Bolivian cotton planted 5 years ago produced a little over 2 oz. per tree, but was badly attacked by scale insects.

SOIL MOISTURE.

72. *Capillarity*.—With a view of determining the depth at which the subsoil water was from the surface of the soil at various points on the farm, some of the old wells on the dry area of the farm were retained and some new ones were dug. One of these new ones was about 450 feet from the edge of the tank where the surface of the soil was 4 feet 7 inches higher than the high water level of the tank and a little over 13 feet above the bottom of the tank. This well was surrounded by a little bund to prevent the surface water running into it. Throughout the season the water in it never dropped below 6 feet 6 inches from the surface even when the tank was dry and as a rule was within 3 feet of the surface. Notwithstanding this the surface soil around the well never appeared to be excessively wet at any time. And in the beginning of the dry season the surface soil of the area around this well in which the water stood at 1 foot 7 inches from the surface at that time did not appear to have more moisture than that of other parts of the field where the surface of the subsoil water was 5 feet or 10 feet or even 25 feet below the surface of the soil. If, as it appeared to be, the soil at the surface was really as dry near this spot where the subsoil water was so near the surface, it would of course indicate that the capillarity of this soil is not nearly as great as the capillarity of soils in general is supposed to be.

73. On November 26th, a boring was made close to this well and the moisture determined in every successive 3 inches of soil. Beginning with the sample extending from the surface to 3 inches below it, the following figures give the percentage of water found in the successive layers of soil:—3·62, 6·31, 10·64, 13·65, 14·33, 14·85. The last of these samples just touched the subsoil water.

74. The soil is a laterite loam. No physical analysis was made of these particular samples, but in appearance they closely resemble a soil from the neighbourhood having the following composition:—

Approximate size of particles	Equivalent to remaining on top of a sieve having about the following No. of meshes to the linear inch	Per cent
Larger than 4 mm in diameter	5	0·00
Between 2 mm and 4 mm $\frac{1}{8}$	10	1·34
" 1 " " 2 mm $\frac{1}{8}$	20	5·13
" $\frac{1}{2}$ " " 1 mm $\frac{1}{8}$	40	6·54
" $\frac{1}{4}$ " " $\frac{1}{2}$ mm $\frac{1}{8}$	60	10·34
" $\frac{1}{8}$ " and $\frac{1}{4}$ mm $\frac{1}{8}$	90	18·90
Particles settled to the bottom of a bottle containing 8 inches of water in the following periods of time—		
$\frac{1}{4}$ minute on an average about $\frac{1}{32}$ inch in diameter		10·11
1 do do $\frac{1}{64}$ do		5·39
10 do do $\frac{1}{128}$ do		9·30
After 10 minutes do $\frac{1}{256}$ do		29·83

75. On December 5th, samples of soil were again taken for moisture determinations. This time a separate sample was taken every $1\frac{1}{2}$ inches in three different places on the field. Series 1. was taken within 4 feet of the shallow well in which the water stood on that date 1 foot 7 inches below the surface of the soil. Series No. 3 was taken 230 feet further away from the tank, near another well in which the water stood 5 feet 6 inches from the surface of the soil, and Series No. 2 was taken at a point midway between these two:—

Depth at which the sample was taken	Per cent of water.		
	Series 1	Series 2	Series 3
Surface to $1\frac{1}{2}$ inches deep	1'94	1'87	1'90
From $1\frac{1}{2}$ inches deep to 3 inches deep	2'07	2'84	3'77
Do 3 do to $4\frac{1}{2}$ do	3'63	3'59	2'91
Do $4\frac{1}{2}$ do to 6 do	4'47	3'49	4'50
Do 6 do to $7\frac{1}{2}$ do	7'57	4'34	5'83
Do $7\frac{1}{2}$ do to 9 do	9'42	4'81	6'59
Do 9 do to $10\frac{1}{2}$ do	10'95	5'53	9'41
Do $10\frac{1}{2}$ do to 1 foot deep	11'77	5'35	10'11
Do 1 foot deep to 1 foot and $1\frac{1}{2}$ inches deep	12'55	5'67	11'35
Do 1 foot $1\frac{1}{2}$ inches deep to 1 foot 3 inches deep	13'26	5'69	11'81
Do 1 do 3 do to 1 do $4\frac{1}{2}$ do	13'80	6'59	12'27
Do 1 do $4\frac{1}{2}$ do to 1 do 6 do	14'10	7'41	12'64
Do 1 do 6 do to 1 do $7\frac{1}{2}$ do	14'99	9'27	12'38
Do 1 do $7\frac{1}{2}$ do to 1 do 9 do	15'05	10'18	12'93
Do 1 do 9 do to 1 do $10\frac{1}{2}$ do	...	10'72	13'14
Do 1 do $10\frac{1}{2}$ do to 2 do deep	...	10'99	13'73

76. As far as these figures go there is nothing to indicate that the top 5 or 6 inches of soil at the place where the surface of the subsoil water was only one foot and seven inches from the surface contained more water than those in places where the subsoil water was much lower. There appears, however, to be something abnormal about Series No. 3. For, although these samples were taken within a few feet of a well in which the water stood at 5' 6" from the surface, the water content of the samples below 2' rapidly rose until it reached 15'37 % of water at a depth of 3' 3". Then it remained almost constant till the level of the water in the well was reached and no further samples were taken. In Series No. 2 water was reached as four feet and, as in Series No. 1, the samples contained 12 % or a little less water to within about 6" of the subsoil water level. Lack of time and appliances unfortunately prevented a more detailed study of this important problem on soils *in situ*.

77. Similar soils were filled into glass tubes. The lower end of these glass tubes when in a vertical position were immersed into water with the object of seeing how quickly and how far the water would rise in the soil contained in these tubes. In 24 hours it rose to 14 inches and in one case to 18 inches above the surface of the water into which these tubes were dipped. After that it rose very slowly, reaching in three weeks from 22 inches to 24 inches in height. These results confirm those obtained on soils *in situ*. Both appear to indicate that on soils like those experimented with the subsoil water has practically no effect in supplying water to the plant unless it is within two feet of the point to which roots descend.

78. *Drying out of soils.*—In order to make a preliminary study of this subject, 24 borings were made to a depth of 6 feet at various times on plots in the Laboratory compound. These plots were uniformly treated up to November 1st 1906. The surface soil had been kept loose to a depth of about 4" for about two months. On October 14th, the first boring was made and the moisture determined in every 6" of soil. On November 1st, one plot was rolled heavily so as to represent uncultivated soil. Another plot was kept stirred on the surface to a depth of about 1½ inches. A third plot was dug to a depth of about 1½ feet and on a fourth plot Bengal gram was sown.

79. Borings were made on these plots from time to time up to February 6th, 1907. The percentage of water found at various depths is given in Table No. XI in the Appendix. Nearly 400 samples of soil were taken and their water content ascertained. During the time that this work was being carried out a number of small showers of rain fell. Table No. XII, kindly sent by the Director of the Meteorological Department, gives the rainfall during this time. The rain gauge is within 300 feet of these plots.

80. The average depths to which the effect due to the evaporation of water from the surface of the soil could be distinctly noticed was as follows :—

Uncultivated plot	Cultivated 1½ inch deep	Cultivated 1½ feet deep
1 foot 9 inches	1 foot 6 inches	1 foot 6 inches

The last borings were taken nearly 1 month after the last shower of rain fell. In these the effect due to the loss of water by evaporation did not extend to more than 1' 6" in either of the cultivated plots. But in the uncultivated plot it probably extended to about 2' 6" depth, and possibly further than that.

81. The Bengal gram was only a light crop. The soil in the laboratory compound is very poor and no manures were used. Notwithstanding this the loss of moisture from the plot on which this crop grew was very much greater than from any of the other plots. Only one boring was taken on that plot and it is therefore not safe to draw deductions from it until confirmed. It appears to indicate, however, that even this light crop of Bengal gram drew on the water supply of the soil to a depth of more than 6 feet. The difference in moisture between the gram plot to a depth of 6 feet and the uncultivated plot would have been compensated for by an application of 3 inches of water over the entire plot and between it and the plot cultivated 1½ inches deep by an application of about 5½ inches of water. The total loss of water by evaporation percolation, etc., during the period from October 14th to February 6th, amounted, when considering only the two feet of soil nearest the surface on the uncultivated plot, to about two inches in excess of the rainfall, to about 1' 6 inches on the plot dug 1½ feet deep and about 1' 5 inches on the plot cultivated 1½ inches deep. Keeping the surface soil loose for 1½ inches acted, therefore, in this instance as well in preserving soil moisture as keeping it stirred 1½ feet deep. The extra loss of water from the upper two feet of the uncultivated soil in this experiment amounted only to the equivalent of about half an inch of rainfall during the time required for the experiment. The saving of such a small amount of moisture can, I think, hardly account fully for the great advantage constant cultivation is known to have upon the growth of crops, unless the moisture content causing the most vigorous growth in this particular soil lies much below 12%, and comparatively slight differences in the water content of the soil have a very marked influence on the growth of plants. The fact that in the pot culture experiments a mulch produced a beneficial result on the crop (*vide* para 91, page 18 of this report), notwithstanding that the water content of the soil was practically constant, also appears to indicate that keeping the surface of the soil loose has other beneficial effects than that of preserving moisture in the soil. It is, therefore, a subject requiring further investigation.

82. A glance at Table No. 11 will show that the water content of these soils does not increase uniformly with their depth. The variations are probably due to

the mechanical condition of the soil not being uniform. It will also be noticed that the soil has a tendency to retain about 12% of water up to within 2 feet of the surface.

83. The work will be continued next year.

POT-CULTURES.

84. As mentioned in para 51, page 25 of last year's report, experiments with bone meal were begun in the pot-culture house with a view of determining if possible the factors which contribute to make bone meal a comparatively readily available phosphatic fertilizer. The fact that bone decomposed very readily on one estate on which it had been applied on the surface of the soil on top of a layer of leaves, while on another estate, on which it had been buried in pits, it had not completely decomposed in 29 years, led me to the idea that either the carbonic acid of the decomposing leaves or the micro-organisms which develop in the decomposing leaves had something to do with the decomposition of the bone meal on the one estate referred to. On that estate there is a, more or less, continuous leaf fall from the coffee and the shade trees growing on it, so that the bones were soon covered by a layer of leaves which kept them moist and retained the carbonic acid generated by the decomposing leaves below.

85. To imitate this condition leaf mould, as generally used by the gardeners, was used on some of the pots and ground sugar cane refuse (begasse) on others. As the soil used for these experiments had not been tested in regard to its manurial requirements and there was no certainty that phosphatic fertilizers were required by the soil, the bone meal used for these experiments was coarse enough to permit all which had not been decomposed to be sifted out of the soil again after the experiment was over. The difference between the weight applied and the amount sifted out again would, it was supposed, indicate fairly accurately the amount decomposed. By this means it was hoped to be able to determine the rate of decomposition of the bone meal in the various pots, even if the soil did not respond to phosphatic fertilizers. For the sake of comparison some fine bone meal was also used.

86. All the usual precautions, necessary to obtain reliable results with pot-cultures, were taken. But unfortunately neither the vegetable mould, which by the way contained 75 % of sand, nor the begasse decomposed to any appreciable extent. The results do not, therefore, give the information desired, and a new set of experiments has been started on a larger scale. The experiments which have been made are, however, of value on account of other information which can be gathered from them.

87. For all the experiments made during the year 16.6 grams of bone meal were used in each pot. The coarse bone meal varied from 2 mm. to 5 mm. in diameter and the fine bone meal had all passed through a sieve having 40 meshes to the linear inch. In some experiments the bone meal was mixed with the top two inches of soil. In others it was applied on the surface of the soil. In the latter experiments the bone meal was covered with either 8 ounces of leaf mould or 3 ounces of ground begasse. Some of the pots in which the bone meal was mixed with the soil were also covered with begasse.

88. The following is the average weight of the bone meal sifted out of the soil from these pots after the experiment was concluded:—

How the bone meal was applied	Bone meal sifted out by using 1 mm. sieve	Bone meal which passed through 2 mm. sieve
Mixed with top 2 inches of soil uncovered	gr. 14.6	gr. 0.37
" " covered with begasse	14.2	0.98
Bone applied on top covered with begasse	15.2	0.24
Bone applied on top covered with leaf mould	14.3	0.67

89. As might have been expected under the circumstances, none of these figures show any rapid decomposition of the coarse bone meal. In these experiments the

bone meal mixed with the soil had decomposed a little more than that applied to the surface; and a covering of leaf mould had a slightly better effect than that of begasse. Probably the former decomposed a little more than the latter. It was of course impossible to remove either mulch from the surface of the soil without removing a little of the soil as well. And the results of the experiments did not justify the analysis of either the leaf mould or begasse after the experiment was concluded.

90. The crop returns were as follows:—

Manures applied to pots	Dry matter	
	In straw gr.	In grain gr.
1. No manure	5'7	281
2. No manure covered with 3 oz. begasse	9'4	5'63
3. No manure covered with 8 oz. leaf mould	10'5	7'45
4. Dried blood and sulphate of potash	132'2	43'70
5. Dried blood and sulphate of potash covered with begasse	134'0	48'99
6. Fine bone meal, dried blood and sulphate of potash all mixed with soil (uncovered)	137'8	56'26
7. Coarse bone meal, dried blood and sulphate of potash all mixed with soil (uncovered)	125'5	49'22
8. Coarse bone meal, dried blood and sulphate of potash, bone meal on top of soil, covered with begasse	131'5	50'39
9. Coarse bone meal, dried blood and sulphate of potash, all mixed with soil, covered with begasse	139'5	52'8
10. Fine bone meal, dried blood and sulphate of potash, all mixed with soil and covered with begasse	136'0	57'5

91. These results indicate that a mulch of begasse has a slight beneficial result on the growth of ragi (the crop used for these experiments), and that a mulch of leaf mould has a somewhat greater beneficial effect than the begasse. This is the case, notwithstanding that none of the plants suffered for want of water, for the pots were watered every day and all the water lost by evaporation during the day was replaced in the evenings. This beneficial result is seen throughout the series and may be noticed by comparing the returns for the unmanured pots, No. 1, 2 and 3; the pots manured only with sulphate of potash and dried blood No. 4 and 5; those in which fine bone meal was also used, 6 and 10; and those in which coarse bone meal was used instead, viz., No. 7 and 9. Experiments Nos. 4 and 7 and Nos. 5 and 9 show that the coarse bone meal has had some effect on the crop, though a comparatively small one. And Nos. 6 and 7 and Nos. 9 and 10 show that the fine bone meal was more effective than the coarse bone meal used. These results are particularly interesting on account of the complete harmony which exists between them. There is not a contradictory result among them. And as this is the first series of pot-culture experiments conducted here, this is particularly encouraging, notwithstanding that it has given very little information on the principal point for which these experiments were started.

92. *Preparation of soil for pot-culture work.*—In order to conduct pot-culture experiments with manures such as attempted this year it is necessary to have a soil in which the particular manures selected for experiment act to advantage. In other words the soil must be deficient in that particular ingredient of plant food with which experiments are to be carried out. Of course such soils exist naturally, but to find them sometimes necessitates a large number of analyses and a considerable number of preliminary experiments. Besides, it generally implies shipping them some distance, and sometimes shipping them from a place very far away. To overcome these difficulties, as far as possible, it is generally advisable to prepare soils artificially for

these experiments. This is done by manuring as poor a soil as can be conveniently secured in a one-sided way and cropping it for successive years as much as possible. This will gradually remove the available plant food in the direction desired. If, for example, a soil already relatively poor in phosphoric acid is heavily manured with all the other constituents of plant food and continuously cropped (if possible with a plant making heavy demands on the phosphoric acid content of the soil) the available phosphoric acid will gradually be reduced to a point where the plant will not be able to get a sufficient supply of phosphoric acid for its normal growth. When that point is reached the soil can be used to advantage for such experiments as testing the relative availability of bone meal, superphosphates, basic slag and other phosphatic fertilizers; or for conducting such experiments as the availability of bone meal under different conditions as was attempted during the year which has just closed.

93. For the purpose of exhausting soils in any desired direction six pits 8' x 10' were built of stone. These were refilled to within 1' 9" from the top and on top of this strips of Cuddappah slabs 1½" thick and 9" wide were set on their edge 9" apart. The refilling was then continued to the upper edge of these strips. The remaining foot was filled in with the soil selected for the one-sided exhaustion to fit it for a particular line of pot-culture experiments. The strips of the Cuddappah slab form, in a way, a perforated bottom to the pits in question, and indicate the depth to which the soil may be removed when dug out for use in the pot culture house.

94. On these "preparation beds," as the above plots are called, the first crop is now growing.

"FAMINE FOODS."

95. In response to a Government Order, "famine foods" were collected by the Revenue and Forest Departments and sent to this laboratory for analyses.

96. A reference to this work was made in para 52, page 26 of the Fifth Annual Report.

97. Since then a large number of samples of so called "famine foods" have been received. Sometimes these samples arrived in very bad condition so that it was necessary to ask the senders to supply other samples. All of these samples have not yet been received, and some samples are likely to come in even now. The samples are therefore not yet complete; among other things the fruit of the prickly-pear, which is said to have been successfully used as a "famine food" has not yet been sent. Moreover, there has been so much work which had to be attended to at once that many of the samples already received have not yet been analysed. However, a sufficient amount of work has been done to justify the results obtained thus far being given in this report.

98. All samples received were sent to Mr. Cameron, Superintendent of Government Gardens, for identification, and all the botanical names are given on his authority.

99. From the list of samples sent in, as given in the appendix, it is evident that the term "famine food" conveys a different meaning to different people, for among the samples received was the ordinary paddy, which few would be prepared to classify under the head of "famine foods." But, as in the absence of a precise definition of the term, it is impossible to draw a sharp line of division between ordinary foods and famine foods, I have included everything sent in as a "famine food" in the tables given in the appendix.

100. Besides their food value, it would be desirable, as pointed out in the Fifth Annual Report, to determine if any of them had an injurious effect on the system if eaten for some time. But if it is remembered that this entails a long series of feeding experiment under close medical supervision, it will be apparent that this is impossible at present.

101. One of the chief points to be considered about "famine foods" is, no doubt, whether they can be got in large quantities during a famine time.

102. Of the "foods" given in Table No. XIII young bamboo shoots are the most nutritious. The air-dried sample appears to be nearly as valuable as gram or dhal, and decidedly more valuable than either rice or ragi. But unfortunately

the young shoots contain only a little over $7\frac{1}{2}$ per cent dry matter. This implies that more than 10 lbs. of green shoots will have to be eaten to supply as much nourishment as is contained in one pound of gram or dhal.

103. The shoots analysed were those of the young bamboos when just above ground. The outer covering was removed and the succulent tender part inside was analysed. The weight of these varies, of course, considerably, but none of them are very large. An average shoot removed from a clump of small bamboos growing to a height of about 10 feet weighed, when prepared, a little over half an ounce.

104. Babul seeds have the highest nitrogen content of all those "famine foods" sent us in which that constituent has been determined. And this notwithstanding that more than half their weight consists of a very hard covering nearly $\frac{1}{2}$ of an inch thick. They contained over 6 per cent nitrogen. When boiling the seeds for three-quarters of an hour or more they rise to the surface of the water and the skin can then be easily cut with a knife, but it is doubtful if even then the skins are digestible. The inside of the seed has a pleasant dhal-like taste, and if any means can be devised for getting this out of its thick hard covering it will probably rise to the rank of an ordinary food, if sufficient quantities of it can be obtained and it has no injurious effect on the system. When boiled for one hour or more the skins are soft enough to be easily eaten.

105. Table No. XIII in the appendix gives the composition of 21 of the so-called "famine foods." The albumenoids have been calculated from the total nitrogen. The non-albumenoid nitrogen has not been determined. The total nitrogen of 44 other "famine foods" has been given in Table No. XIV, and Table No. XV gives such general information about the "famine foods" received up to date as is available at present.

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